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# METHOD OF CALCULATING SOIL TEMPERATURE AT A DEPTH OF 5 cm FROM ATMOSPHERIC TEMPERATURE AND HUMIDITY VALUES

L. V. Popovich

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# METHOD OF CALCULATING SOIL TEMPERATURE AT A DEPTH OF 5 cm FROM ATMOSPHERIC TEMPERATURE AND HUMIDITY VALUES

L. V. Popovich

ABSTRACT. The application of a method for soil temperature determination, previously proposed, is discussed, calculations are made, and graphs and charts are compiled for use in determining soil temperature at a depth of 5 cm under natural cover.

Study of the temperature regime in the arable layer of the soil, that in /89* which the main mass of plant roots is found, is of practical value for agricultural production. Intensity of growth, and plant development [1], definitely depend on soil temperature, particularly during the initial period of vegetation development. The thermal regime in the soil has a great influence on the rate at which biological and biochemical processes take place in the soil, and hence on soil fertility. Consequently, soil thermal conditions play an important part in the complex set of agrometeorological characteristics determining crop yields.

The possibility of determining the conditions of the soil temperature regime, averaged for a definite area, is of great practical importance, and something that cannot always be done by direct measurement. The proposed method of making the calculation provides the characteristics of the temperature regime, the average for meteorological areas covered by a natural plant cover (grassland) that is cut from time to time. The basis for this method of making the soil temperature determination was set forth in earlier articles by the author [3, 4]. These papers pointed out that so-called inertia, that is, delay (shift in phases) in daily and seasonal air temperature variations at a height of 2 meters as compared to the variation in soil temperature at the depth considered, had to be taken into consideration in order to establish the quantitative connection between air temperature and soil temperature.

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* Numbers in the margin indicate pagination in the foreign text.

This paper applies the procedure set forth earlier for calculating the mean 10-day values of soil temperature at a depth of 5 cm at 0100, 0700, 1000, 1300, and 1900 hours.

Data on air temperature and humidity at a height of 2 meters, and the temperature of the soil at a depth of 5 cm under natural plant cover (grassland), were used to find the empirical relationships. Mean 10-day air temperature minima and maxima at a height of 2 meters were taken from extremal thermometer readings. All observation data were obtained from meteorological stations in different physical and geographic zones in the Ukrainian SSR (Askaniya-Nova, Borispol', Beregovo, Bolgrad, Veliko-Anadol', Poltava) for the period 1957-1959, April-November, inclusive. Overall, 940 cases of mean 10-day temperature values were used. /90

First to be studied was the inertia in the daily variation in air temperature and humidity at a height of 2 meters, and in soil temperature at 5 cm. This was done by a detailed plotting [2, 3] of curves for the daily variation in these elements from the mean 10-day values for six observation times (0100, 0700, 1000, 1300, 1600 and 1900 hours). These curves, even in their external appearance, show a delay in soil temperature maxima at 5 cm as compared to the maximum air temperatures at a height of 2 meters. The curves for daily variation in soil temperature at 5 cm were replotted at a different scale to bring their daily variation amplitudes into coincidence with the same amplitudes in the air, so as to include the real delay in all the other corresponding temperature phases that can differ from the delay for the maxima at different times. The correction factors for daily inertia in heat transfer between air temperature at 2 meters and soil temperature at 5 cm were taken from these curves and plotted in terms of air temperature and humidity values. The result was an individual correction factor nomogram for each time of observation. These relationships are presented at the end of this paper in the form of tables (Appendix I).

The delay in the onset of extremal temperatures at 5 cm, as compared to air temperature at 2 meters, is shorter than it is at the 10 and 20 cm levels, so the magnitudes of the correction factors for the depth were changed accordingly. Correction factors calculated for the 5 cm level were smaller in absolute values for all times than were the same factors calculated for the 10 and 20 cm depths. Correction factor maxima (-2, -6°C) were a maximum in the morning hours (0700, 1000), at which time the maximum lag in the phase of soil temperature oscillations behind the corresponding phase in the air was observed.

The intensity in the heat transfer from the surface of the soil decreases, as does the difference between soil and air temperatures, during the second half of the day. The correction factors for 1300 and 1900, for example, decrease to 1.0 - 0.1°. The least correction factor (0.1 - 0.5°) is observed at 0100 (Appendix I).

Daily correction factors for humidity, calculated similarly [3, 4], were insignificant, in absolute terms. It was virtually impossible to fair in /91
isolines on the majority of the curves constructed for each of the six times of observations because a homogeneous field of correction factors close to measurement errors, in absolute terms, was found for almost all observation times.

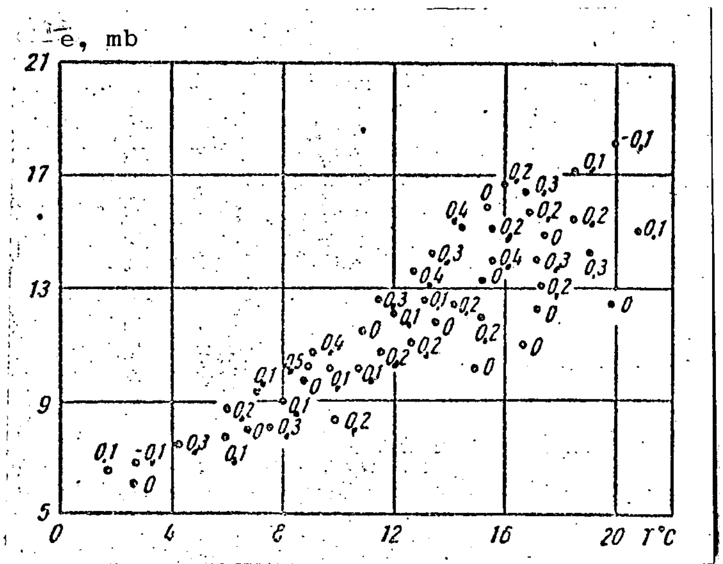


Figure 1. Magnitudes of daily correction factors for air water vapor pressure for 0100 hours.

Figure 1 shows the values for the magnitudes of the correction factors for humidity at 0100 hours. Air temperature is plotted on the x-axis, air water vapor pressure on the y-axis. As we see, the correction factor for this time ranges from -0.1 to 0.4 mb. The maximum error in determination of the water vapor pressure from the humidity tables is ±0.3 mb, if the dry and wet-bulb temperature readings are accurate to within 0.1°. These correction factor magnitudes cannot, therefore, be taken into consideration. The exception is the 1000 observation, at which time isolines from -0.5 to 1.5 mb can be drawn. But even these correction factor magnitudes are but an insignificant part of the eigenvalue of the air water vapor pressure. It therefore is possible to ignore possible correction factors for inertia in the daily variation in air humidity. Determination of soil temperature at a depth of 5 cm then become much simpler than is the case for depths of 10 and 20 cm.

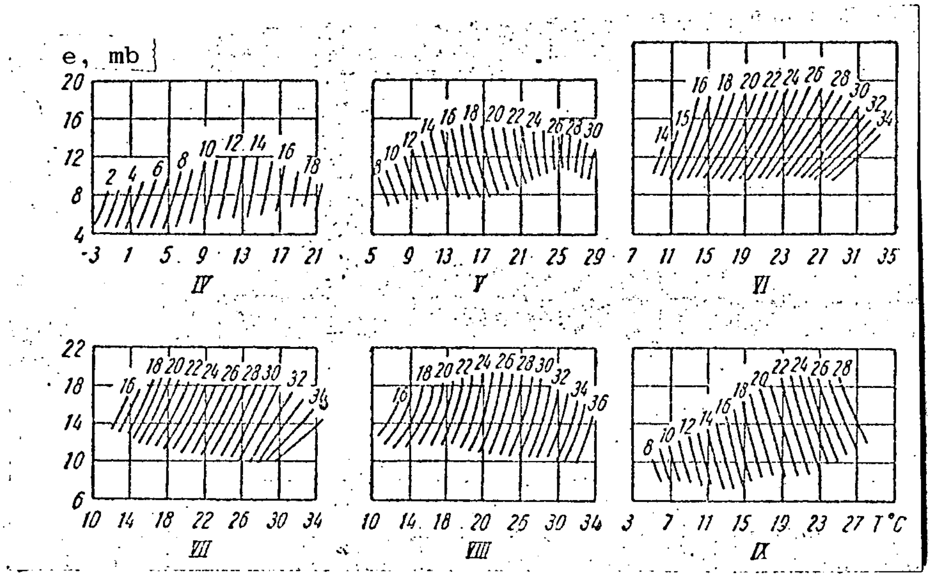


Figure 2. Curves from soil temperature calculations at 5 cm for individual months.

A series of curves were constructed (Figure 2) to calculate soil temperature. Air temperature at a height of 2 meters, corrected for daily inertia in heat transfer, was plotted on the x-axis, and uncorrected humidity values were plotted on the y-axis. Graphical relationships were constructed for each of the months /92 April through October, precluding the need to consider seasonal corrections for air temperature and humidity. Mean 10-day values of soil temperature, determined from Figure 2 and measured for the same times, were compared in order to evaluate the accuracy of the soil temperature calculation curves thus obtained. The comparison was made using data from the stations providing the observations used to construct the curves, but for a different period. Overall, 60 verifying calculations were made for each of the graphics in Figure 2. Absolute error distribution curves were approximately symmetrical, indicating an absence of systematic errors. Root-mean-square deviations ($\sigma$) in calculated temperatures from measured temperatures also were calculated. $\sigma$ was the same for each of the months: April 1.6°, May 1.3°, June 1.6°, July 1.6°, August 1.4°, September 2.1°.

Table 1 list the probability of different magnitudes of deviations in actual temperatures from those calculated from the curves in Figure 2.

TABLE 1. PROBABILITY OF DEVIATION (%) IN CALCULATED SOIL TEMPERATURE VALUES FROM MEASURED VALUES

| Months | Magnitude of deviation, °C | | | | |
|---|---|---|---|---|---|
| | 0–1.0 | 1.1–2.0 | 2.1–3.0 | 3.1–4.0 | 4.1–5.0 |
| April | 44.4 | 35.5 | 13.3 | 2.2 | 4.4 |
| May | 63.3 | 23.3 | 10 | 1.6 | 1.6 |
| June | 41.6 | 38.3 | 11.6 | 3.3 | 5.0 |
| July | 53.3 | 28.3 | 6.6 | 6.6 | 3.3 |
| August | 60 | 25 | 8.3 | 3.3 | 3.3 |
| September | 38.3 | 31.6 | 15 | 8.3 | 6.6 |

Data provided by the Poltava meteorological station for the 0700 observations for May 1964, will be used as an example of the calculation. Air temperature and humidity values at a height of 2 meters, averaged for the first 10-day period, were 10.8° and 9.3° mb, respectively. Appendix I provides the air temperature correction factor $\Delta T = -2.7°$. The corrected air temperature value will be /93

$$T' = T_{2m} + \Delta T = 10.8° - 2.7° = 8.1°$$

Using the coordinates $T' = 8.1°$ and $\bar{e} = 9.3$ mb in Figure 2 for May, we determine the soil temperature at a depth of 5 cm to be 10°. The actual soil temperature at the time was 9.3°.

The result of the processing was to obtain general graphical relationships, presented in Figure 2, for different soils and climatic zones, for use in finding the soil temperature at a depth of 5 cm under natural cover. The next stage of the work should be that of investigating the applicability of these curves to concrete forms of underlying surfaces. At the same time it should be emphasized that concretization here will mean seeking correction factors for the procedure developed, making this paper the basis of such future work.

APPENDIX I. MAGNITUDES OF CORRECTION FACTORS (°C) FOR INERTIA IN THE DAILY VARIATION IN AIR TEMPERATURE

| Air temperature °C | Air Water Vapor Pressure, mb | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | 0100 hours | | | | | | | | | | | | | | | |
| 0 | | 0,3 | | | | | | | | | | | | | | |
| 1 | 0,1 | 0,3 | | | | | | | | | | | | | | |
| 2 | | 0,2 | 0,3 | | | | | | | | | | | | | |
| 3 | | 0,1 | 0,3 | | | | | | | | | | | | | |
| 4 | | | 0,2 | 0,3 | | | | | | | | | | | | |
| 5 | | | 0,2 | 0,3 | | | | | | | | | | | | |
| 6 | | | 0,1 | 0,2 | 0,3 | | | | | | | | | | | |
| 7 | | | | 0,2 | 0,3 | | | | | | | | | | | |
| 8 | | | | 0,1 | 0,2 | 0,3 | | | | | | | | | | |
| 9 | | | | 0,1 | 0,2 | 0,3 | | | | | | | | | | |
| 10 | | | | | 0,1 | 0,2 | 0,3 | 0,4 | | | | | | | | |
| 11 | | | | | 0,1 | 0,2 | 0,3 | 0,4 | 0,4 | | | | | | | |
| 12 | | | | | | 0,1 | 0,2 | 0,3 | 0,4 | 0,4 | | | | | | |
| 13 | | | | | | 0,1 | 0,2 | 0,2 | 0,3 | 0,4 | | | | | | |
| 14 | | | | | | | 0,1 | 0,2 | 0,3 | 0,3 | 0,4 | | | | | |
| 15 | | | | | | | 0,1 | 0,2 | 0,2 | 0,3 | 0,4 | 0,4 | | | | |
| 16 | | | | | | | | 0,1 | 0,2 | 0,2 | 0,3 | 0,4 | 0,4 | | | |
| 17 | | | | | | | | 0,1 | 0,1 | 0,2 | 0,3 | 0,3 | 0,4 | 0,4 | | |
| 18 | | | | | | | | | 0,1 | 0,1 | 0,2 | 0,3 | 0,4 | 0,4 | 0,4 | |
| 19 | | | | | | | | | | 0,1 | 0,2 | 0,2 | 0,3 | 0,3 | | |
| 20 | | | | | | | | | | 0,1 | 0,1 | 0,2 | 0,3 | 0,3 | | |
| 21 | | | | | | | | | | | 0,1 | 0,1 | 0,2 | | | |
| 22 | | | | | | | | | | | | 0,1 | 0,2 | | | |

Commas represent decimal points.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 0700 hours | | | | | | | | |
| 0 | —0,1 | | | | | | | | | | | | | | |
| 1 | | —1,0 | | | | | | | | | | | | | |
| 2 | | —1,2 | | | | | | | | | | | | | |
| 3 | | —1,5 | —1,0 | | | | | | | | | | | | |
| 4 | | —1,9 | —1,3 | —0,9 | | | | | | | | | | | |
| 5 | | —2,3 | —1,7 | —1,1 | | | | | | | | | | | |
| 6 | | —2,6 | —2,0 | —1,5 | —1,0 | | | | | | | | | | |
| 7 | | —3,0 | —2,5 | —2,0 | —1,4 | —0,9 | | | | | | | | | |
| 8 | | —3,3 | —2,8 | —2,3 | —1,8 | —1,2 | | | | | | | | | |
| 9 | | —3,6 | —3,2 | —2,7 | —2,2 | —1,6 | —1,1 | | | | | | | | |
| 10 | | —4,0 | —3,6 | —3,0 | —2,5 | —2,0 | —1,5 | | | | | | | | |
| 11 | | | —3,9 | —3,4 | —3,0 | —2,5 | —2,0 | —1,5 | | | | | | | |
| 12 | | | —4,3 | —3,8 | —3,4 | —2,8 | —2,4 | —2,0 | —1,5 | | | | | | |
| 13 | | | —4,6 | —4,1 | —3,7 | —3,2 | —2,8 | —2,3 | —2,0 | | | | | | |
| 14 | | | —4,9 | —4,5 | —4,0 | —3,5 | —3,2 | —2,7 | —2,3 | —1,9 | | | | | |
| 15 | | | | —4,7 | —4,3 | —3,8 | —3,5 | —3,0 | —2,6 | —2,3 | —2,0 | | | | |
| 16 | | | | —5,0 | —4,6 | —4,2 | —3,8 | —3,4 | —3,0 | —2,6 | —2,2 | —2,0 | | | |
| 17 | | | | | —4,9 | —4,5 | —4,0 | —3,7 | —3,3 | —2,9 | —2,5 | —2,2 | —2,0 | | |
| 18 | | | | | | —4,8 | —4,4 | —4,0 | —3,6 | —3,2 | —2,9 | —2,5 | —2,3 | —2,0 | |
| 19 | | | | | | —5,0 | —4,7 | —4,3 | —4,0 | —3,6 | —3,2 | —2,9 | —2,5 | —2,3 | —2,0 |
| 20 | | | | | | | —5,0 | —4,6 | —4,2 | —3,8 | —3,5 | —3,2 | —2,9 | —2,6 | —2,3 |
| 21 | | | | | | | | —4,9 | —4,6 | —4,2 | —3,9 | —3,5 | —3,2 | —3,0 | —2,6 |
| 22 | | | | | | | | | —4,8 | —4,5 | —4,1 | —3,8 | —3,5 | —3,2 | —2,9 |
| 23 | | | | | | | | | —5,1 | —4,3 | —4,5 | —4,1 | —3,8 | —3,5 | —3,2 |
| 24 | | | | | | | | | | —5,1 | —4,8 | —4,5 | —4,1 | —3,8 | —3,5 |
| 25 | | | | | | | | | | | —5,1 | —4,7 | —4,5 | —4,1 | |
| 26 | | | | | | | | | | | | —5,0 | —4,7 | —4,4 | |
| 27 | | | | | | | | | | | | | —5,0 | —4,7 | |
| 28 | | | | | | | | | | | | | | —5,0 | |
| | | | | | | | 1000 hours | | | | | | | | |
| 1 | —2,0 | | | | | | | | | | | | | | |
| 2 | | —1,8 | | | | | | | | | | | | | |
| 3 | | —2,1 | —1,6 | | | | | | | | | | | | |
| 4 | | —2,3 | —1,9 | —1,4 | | | | | | | | | | | |
| 5 | | —2,5 | —2,1 | —1,6 | —1,2 | | | | | | | | | | |

Commas represent decimal points.

APPENDIX I CONTINUED

| Air temperature, °C | Air Water Vapor Pressure, mb | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | 1000 hours | | | | | | | | | | | | | | | |
| 6 | | —2,8 | —2,4 | —2,0 | —1,5 | —1,0 | | | | | | | | | | |
| 7 | | —3,0 | —2,5 | —2,2 | —1,7 | —1,2 | | | | | | | | | | |
| 8 | | —3,2 | —2,8 | —2,4 | —2,0 | —1,5 | —1,0 | | | | | | | | | |
| 9 | | —3,5 | —3,0 | —2,6 | —2,2 | —1,7 | —1,2 | | | | | | | | | |
| 10 | | | —3,2 | —2,8 | —2,4 | —2,0 | —1,5 | —1,1 | | | | | | | | |
| 11 | | | —3,4 | —3,0 | —2,6 | —2,3 | —1,8 | —1,4 | —1,0 | | | | | | | |
| 12 | | | —3,6 | —3,2 | —2,9 | —2,5 | —2,0 | —1,6 | —1,2 | | | | | | | |
| 13 | | | | —3,5 | —3,0 | —2,7 | —2,3 | —1,9 | —1,5 | —1,0 | | | | | | |
| 14 | | | | —3,6 | —3,3 | —2,9 | —2,5 | —2,2 | —1,7 | —1,3 | | | | | | |
| 15 | | | | | —3,5 | —3,1 | —2,7 | —2,4 | —2,0 | —1,5 | —1,1 | | | | | |
| 16 | | | | | —3,7 | —3,3 | —3,0 | —2,6 | —2,2 | —1,8 | —1,4 | —1,0 | | | | |
| 17 | | | | | —3,9 | —3,5 | —3,2 | —2,8 | —2,5 | —2,1 | —1,7 | —1,3 | | | | |
| 18 | | | | | —4,1 | —3,7 | —3,4 | —3,1 | —2,7 | —2,4 | —2,0 | —1,5 | —1,2 | | | |
| 19 | | | | | | —4,0 | —3,6 | —3,3 | —2,9 | —2,6 | —2,2 | —1,8 | —1,5 | —1,0 | | |
| 20 | | | | | | —4,2 | —3,8 | —3,5 | —3,2 | —2,8 | —2,5 | —2,1 | —1,7 | —1,3 | —1,0 | |
| 21 | | | | | | —4,5 | —4,0 | —3,7 | —3,4 | —3,0 | —2,7 | —2,4 | —2,0 | —1,7 | —1,3 | |
| 22 | | | | | | —4,7 | —4,3 | —3,9 | —3,6 | —3,2 | —2,8 | —2,6 | —2,3 | —2,0 | —1,6 | —1,1 |
| 23 | | | | | | —5,0 | —4,5 | —4,2 | —3,8 | —3,5 | —3,1 | —2,8 | —2,5 | —2,2 | —1,8 | —1,5 |
| 24 | | | | | | | —4,8 | —4,4 | —4,0 | —3,7 | —3,4 | —3,0 | —2,7 | —2,4 | —2,1 | —1,7 |
| 25 | | | | | | | —5,0 | —4,6 | —4,2 | —3,8 | —3,6 | —3,3 | —2,9 | —2,7 | —2,4 | —2,0 |
| 26 | | | | | | | —5,2 | —4,8 | —4,5 | —4,2 | —3,8 | —3,5 | —3,2 | —2,9 | —2,6 | |
| 27 | | | | | | | —5,4 | —5,1 | —4,7 | —4,4 | —4,0 | —3,7 | —3,5 | —3,1 | —2,8 | |
| 28 | | | | | | | —5,6 | —5,3 | —5,0 | —4,7 | —4,3 | —3,9 | —3,7 | —3,4 | | |
| 29 | | | | | | | | —5,6 | —5,2 | —4,8 | —4,5 | —4,2 | —3,8 | —3,5 | | |
| 30 | | | | | | | | —5,8 | —5,5 | —5,1 | —4,7 | —4,4 | —4,0 | | | |
| 31 | | | | | | | | —6,1 | —5,7 | —5,4 | —5,0 | —4,6 | | | | |
| 32 | | | | | | | | | —6,0 | —5,7 | —5,2 | —4,8 | | | | |
| 33 | | | | | | | | | | —5,9 | —5,5 | | | | | |

Commas represent decimal points.

1300 hours

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | |
| 7 | | 0,0 | | | | | | | | | | | | | | |
| 8 | | 0,0 | | | | | | | | | | | | | | |
| 9 | | —0,1 | 0 | | | | | | | | | | | | | |
| 10 | | | 0 | | | | | | | | | | | | | |
| 11 | | | —0,1 | | | | | | | | | | | | | |
| 12 | | | —0,1 | 0,0 | | | | | | | | | | | | |
| 13 | | | —0,2 | —0,1 | | | | | | | | | | | | |
| 14 | | | —0,3 | —0,2 | 0,0 | | | | | | | | | | | |
| 15 | | | | —0,2 | —0,1 | 0,0 | | | | | | | | | | |
| 16 | | | | —0,3 | —0,2 | —0,1 | 0,0 | | | | | | | | | |
| 17 | | | | —0,4 | —0,3 | —0,2 | —0,1 | | | | | | | | | |
| 18 | | | | | —0,3 | —0,2 | —0,1 | 0,0 | | | | | | | | |
| 19 | | | | | —0,4 | —0,3 | —0,2 | —0,1 | 0,0 | | | | | | | |
| 20 | | | | | —0,5 | —0,4 | —0,3 | —0,2 | —0,1 | 0,0 | | | | | | |
| 21 | | | | | | —0,4 | —0,4 | —0,3 | —0,2 | —0,1 | 0,0 | | | | | |
| 22 | | | | | | —0,5 | —0,4 | —0,3 | —0,2 | —0,2 | —0,1 | 0 | | | | |
| 23 | | | | | | | —0,5 | —0,4 | —0,3 | —0,3 | —0,2 | —0,1 | 0,0 | | | |
| 24 | | | | | | | —0,6 | —0,5 | —0,4 | —0,3 | —0,2 | —0,1 | —0,1 | 0,0 | | |
| 25 | | | | | | | —0,7 | —0,6 | —0,5 | —0,4 | —0,3 | —0,2 | —0,2 | —0,1 | | |
| 26 | | | | | | | —0,7 | —0,6 | —0,6 | —0,5 | —0,4 | —0,3 | —0,2 | | | |
| 27 | | | | | | | —0,8 | —0,7 | —0,6 | —0,6 | —0,5 | —0,4 | —0,3 | | | |
| 28 | | | | | | | —0,9 | —0,8 | —0,7 | —0,6 | —0,6 | —0,5 | —0,4 | | | |
| 29 | | | | | | | —1,0 | —0,9 | —0,8 | —0,7 | —0,6 | —0,6 | —0,5 | | | |
| 30 | | | | | | | | —1,0 | —0,9 | —0,8 | —0,7 | —0,6 | | | | |
| 31 | | | | | | | | | —1,0 | —0,9 | —0,8 | —0,7 | | | | |
| 32 | | | | | | | | | | —1,0 | —0,9 | —0,8 | | | | |
| 33 | | | | | | | | | | —1,1 | | | | | | |

Commas represent decimal points.

| Air Temperature, °C | Air Water Vapor Pressure, mb | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | 1900 hours | | | | | | | | | | | | | | | |
| 4 | 1,0 | 1,1 | 1,2 | | | | | | | | | | | | | |
| 5 | | 1,1 | 1,2 | | | | | | | | | | | | | |
| 6 | | 1,0 | 1,1 | 1,2 | | | | | | | | | | | | |
| 7 | | | 1,1 | 1,1 | | | | | | | | | | | | |
| 8 | | | 1,0 | 1,1 | 1,2 | | | | | | | | | | | |
| 9 | | | 0,9 | 1,0 | 1,1 | 1,2 | | | | | | | | | | |
| 10 | | | 0,8 | 1,0 | 1,1 | 1,2 | | | | | | | | | | |
| 11 | | | 0,8 | 0,9 | 1,0 | 1,1 | 1,2 | | | | | | | | | |
| 12 | | | 0,7 | 0,8 | 0,9 | 1,0 | 1,1 | | | | | | | | | |
| 13 | | | 0,6 | 0,7 | 0,8 | 1,0 | 1,1 | | | | | | | | | |
| 14 | | | | 0,6 | 0,7 | 0,8 | 1,0 | 1,1 | | | | | | | | |
| 15 | | | | 0,5 | 0,6 | 0,7 | 0,9 | 1,0 | 1,1 | | | | | | | |
| 16 | | | | | 0,5 | 0,6 | 0,8 | 0,9 | 1,0 | | | | | | | |
| 17 | | | | | | 0,5 | 0,6 | 0,8 | 0,9 | 1,0 | | | | | | |
| 18 | | | | | | | 0,5 | 0,7 | 0,8 | 0,9 | 1,0 | | | | | |
| 19 | | | | | | | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 | 1,0 | | | | |
| 20 | | | | | | | 0,4 | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 | 1,0 | | | |
| 21 | | | | | | | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 | 1,0 | | |
| 22 | | | | | | | 0,2 | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 | 1,0 | |
| 23 | | | | | | | 0,1 | 0,2 | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 | |
| 24 | | | | | | | 0 | 0,1 | 0,2 | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | 0,8 | |
| 25 | | | | | | | | 0 | 0,1 | 0,2 | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | |
| 26 | | | | | | | | | 0 | 0,1 | 0,2 | 0,3 | 0,4 | 0,5 | 0,6 | |
| 27 | | | | | | | | | | 0 | 0,1 | 0,2 | 0,3 | 0,4 | 0,5 | |
| 28 | | | | | | | | | | | 0 | 0,1 | 0,2 | 0,3 | | |
| 29 | | | | | | | | | | | | 0 | 0,1 | 0,2 | | |
| 30 | | | | | | | | | | | | | 0 | 0,1 | | |
| 31 | | | | | | | | | | | | | | 0 | | |
| 32 | | | | | | | | | | | | | | | | |

Commas represent decimal points.

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